ANNEXE J

water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

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Dear Sir/Madam

AMENDMENT APPLICATION REPORT: ENVIRONMENTAL MANAGEMENT PROGRAMME AMENDMENT APPLICATION DE BEERS CONSOLIDATED MINES LIMITED VOORSPOED DIAMOND MINE, FREE STATE PROVINCE

This office acknowledges receipt of the above-mentioned document dated March 2023 as submitted by GCS Water and Environmental Consultants.

1. BACKGROUND

De Beers Consolidated Mines Proprietary Limited (hereafter referred to as Voorspoed Mine) seeks the removal of three conditions from the Environmental Management Programme Report. The three conditions were included in the approval letter issued by the Free State Regional Office of the Department of Mineral Resources and Energy (DMRE) pertaining to the Voorspoed Mine Environmental Management Programme Report submitted in July 2010 with reference number FS30/5/1/2/3/2/1/12 (EM).

The EMPr was submitted related to backfilling of the final void created resulting from diamond mining activities at the Voorspoed Mine.

The amendment application report serves to motivate for the removal of the following three conditions

- Condition (d): "*All mine waste (suitable for rehabilitation) must be taken back to the excavation area for backfilling purposes. Rehabilitation of the mining area must be done concurrently with mining activities (whenever and wherever possible)*"

- Condition (f): "*Dump structures must not be left on the surface, this includes topsoil stockpiles, overburden stockpiles, waste rock stockpiles, tailings dumps and slimes dams*"; and

- Condition (g): "*All excavations must be backfilled to the natural surface level; if a bulk factor exists it must be accommodated on the total area of disturbance*".

Voorspoed mine must take note that the aim of the rehabilitation of the impacted area is to restore it to the initial land use as far as possible. The pitlake option as suggested by Voorspoed mine is in contradiction with the aim of mine closure or rehabilitation.

According to the Voorspoed Mine Final Closure Plan (Redco and Uvuna Sustainability, 2022), the preferred closure option for the void is for it to be left open to rewater over time and create what is referred to in this report as a "pit lake". It is proposed that the terrain surrounding the pit excavation will be rehabilitated according to the mine's Final Closure Plan (Redco and Uvuna Sustainability, 2022) and the Voorspoed Final Rehabilitation Plan (Redco and Uvuna Sustainability, 2022). A geochemical model is being developed to calculate the pit lake chemistry over time. The geochemical model utilizes the pit lake water balance model described in this memorandum. The geochemical modelling is dependent on source term results generated from the humidity cells.

2. DOCUMENTS ASSESSED

a) Task 8: Voorspoed Pit Lake Characterization – Pit Water Balance compiled by Golder dated September 2022.
b) De Beers Consolidated Mines-Voorspoed Post Closure Geochemical Pit Lake Model, compiled by Golder dated February 2021.
c) Final Closure Plan compiled by Redco and Uvuna Sustainability dated June 2022

3. FINDINGS

a) The current mine pit dimension shows that the Pit bottom elevation is 1163m, while the maximum volume at 1415 masl (meter above sea level 56Mm^3 and the maximum rainfall/runoff footprint is 693,300 m^2).

b) The water sources that have been identified to have a direct impact on the Voorspoed pit include the following:

   i. Groundwater infiltration
   ii. Shallow groundwater and Waste Rock Dump (WRD) seepage
   iii. Deep groundwater which is unimpacted by surface dump seepage
   iv. Direct rainfall
   v. Wall rock flushing from the pit walls above the lake water level
   vi. Inflows from catchments surrounding the pit lakes, in particular the Fine Residue Dump (FRD) seepage to the pit.
   vii. Water losses Evaporation losses are the only outflow expected given that the evaporation in the area far exceeds precipitation annually.

c) Based on the pit water balance no or an insignificant quantity of groundwater seepage is expected, given the low permeability of the rock geology surrounding the Voorspoed pit.

d) A central premise to pit lakes is that the resultant pit lake water quality is influenced by the water qualities of various water sources that flow into the pit lake and their respective volumes. Each of these water sources will have a chemical load (e.g., reactions between pit wall minerals and runoff), which will report to the pit lake and impact pit lake water quality.

e) The following geochemical processes are likely to happen in the pit area:

   i. Surface sorption - (Ferrihydrite surfaces are likely sources for surface adsorption reactions which can remove metal cations and oxyanions from solution, thereby impacting pit lake water quality).

ii. Reactions with the pit lake water and atmospheric gases such as CO_2 and O_2, are very likely to occur in the reactive oxic zone (2-20 m), to simplify the modelling, O_2 reactions were not considered during this phase of the study.

iii. Reactions in the oxic zone are likely to result in a continuous and cyclic transfer of solutes from the deeper regions (>20 m), which will impact the pit lake water quality (e.g., precipitation and dissolution reactions).

iv. Based on the site-specific conceptual model described above (i.e., water sources, inflows, outflows and geochemical processes) the variables required by the hydrogeochemical model, to simulate the water quality of the pit lakes were determined.

f) It was determined that approximately 50% of the pit perimeter is surrounded by the waste rock dump (WRD), and consequently a significant proportion of groundwater seepage to the pit is assumed to originate from seepage from the WRD dump. To accommodate this into the hydrogeochemical modelling, it was assumed that the groundwater inflow into the pit would be made up of 50% WRD seepage and 50% unimpacted groundwater.

g) Pit Scenarios

i. Scenario 1: Pit Lake Filling: In this scenario, the pit lake fills naturally. All surface water is assumed to be diverted away from the pit area. Inputs to the pit thus include rainfall on the pit footprint, groundwater ingress and the output from the pit was losses to evaporation. it was demonstrated that the pit would remain a groundwater sink due to the high evaporation compared with rainfall and groundwater ingress.

ii. Scenario 2: Pit Lake filling with engineered catchment: This is considered the pit lake which receives ingress from rainfall on the pit footprint, groundwater inflows and losses via evaporation as well as additional surface water inflows generated from an engineered catchment measuring 406.2 ha. It is assumed that the catchment will be smoothed and grassed, and accordingly, surface runoff was calculated utilising the SCS method and assigning a curve number of 79. In this scenario, it was demonstrated that the final water level would be 20 - 30 m higher than that simulated for Scenario 1. The pit would however remain as a sink because of the high evaporation.

iii. Scenario 3: Backfilling of the pit: A third scenario was simulated where the pit was assumed to be backfilled. The pit is no longer expected to remain as a sink and pit water is thus expected to migrate away from the pit area to the adjacent aquifer zones.

iv. Based on an evaluation (GoldSET) of these three scenarios it was concluded that the preferred pit lake option is scenario 1. It was determined that scenario 2 will not be environmentally beneficial and the associated costs would be considerably higher with respect to the designed catchment requirement. Similarly, scenario 3 (backfill) was deemed unfavorable in terms of costs associated with backfilling and the potential creation of a contaminant source post-closure. Given the rationale described above, scenario 1 was the option chosen to undertake the hydrogeochemical modelling.

h) Water Quality

- The pH of the pit lake remains in the pH 6-8 range, for the entire 400-year simulation, with the mean pH simulation of the pit lake being higher than the maximum pH simulation.

- The mean and maximum pH simulations fall within the Department of Water and Sanitation domestic (pH=6-9) and irrigation (pH 6.4-8.5) water quality guideline limits.

- Minerals phases that were predicted to precipitate for the mean concentration 400-year simulations were calcite [$CaCO_3$], ferrihydrite [$(Fe_3+)2O30.5H_2O$] and gibbsite [$Al(OH)_3$], with the predicted mineral phases for the maximum concentration 400-year simulation being barite [$BaSO_4$], calcite [$CaCO_3$], ferrihydrite [$(Fe_3+)2O_30.5H_2O$], gibbsite[$Al(OH)_3$], and manganite [MnO(OH)].

- The precipitation of these mineral phases would result in a decrease in TDS and the concentrations of those constituents making up these mineral phases.

- The results of the Total Dissolved Solids (TDS) simulations show that the TDS increases for both the mean and maximum concentrations from year 1 up to year 40 (TDS ≈715 mg/l) and year 1 up to year 41 (TDS ≈ 4900 mg/l) respectively, thereafter decreasing for the duration of the 400-year simulation.

- The mean concentration exceeds the domestic water use TDS limit (TDS=450mg/l) from year 1 up to year 117, thereafter falling below the TDS limit, but is below the livestock water quality guideline limit for the 400-year simulation period.

- The maximum concentration exceeds both the domestic (TDS=450mg/l) and livestock (TDS=1000mg/l) TDS limits for the entire 400-year simulated duration.

- The constituents (i.e., Fluoride (F), Aluminum (Al), Boron (B), Beryllium (Be), Cobalt (Co), Iron (Fe), Lead (Pb) and Zinc (Zn)) did not exceed any of the water quality guideline limits for both the mean and maximum 400-year simulations.

- The constituents (i.e., Nitrate, Sulphate, Arsenic, Calcium, Manganese and Sodium) were found to exceed the domestic use water quality guideline for both the mean and maximum simulations.

- The constituent molybdenum was found to exceed the livestock guideline limit for the mean simulation with sulphate and molybdenum exceeding the livestock guideline limit for the maximum simulation.

- The mean simulation resulted in exceedances of the irrigation guideline limit for Manganese and Sodium with the maximum simulation exceeding the irrigation guideline limit for Copper, Manganese, Nickel and Sodium

- The nitrate concentrations for the mean (≈100mg/l) and maximum (≈300mg/l), show a minimal change for the duration of the 400-year simulation indicating the pit lake is likely to be enriched with nitrates which may result in the eutrophication of the pit lake, even though the phosphate concentration was found to be low.

- Most of the constituents show an initial increase in concentrations during the first ≈50 years, thereafter we see a gradual decrease in concentrations which is likely due to precipitation and surface complexation reactions controlling their concentrations.

- The pit lake is expected to rise rapidly as initial rainfall and groundwater inflows exceed the actual evaporation rates. The pit lake model was calibrated against data collected on three instances since closure in 2018 to the present. There is good agreement between the simulated and measured pit lake levels.

i) The rise in water level at the simulated heads is outlined below: ▪ The rise in the head between 0 - 50 years: 134 m (1163 mamsl (2018) to 1305 mamsl (2068))

i. The rise in the head between 50 -100 years: 23 m (1305 mamsl (2068) to 1331 mamsl (2188))

ii. The rise in the head between 100 - 200 years: 14 m (1331 mamsl (2188) to 1346 mamsl (2288))

iii. The rise in the head between 200 - 300 years: 2 m (1346 mamsl (2288) to 1349 mamsl (2388))

j) The pre-mining hydraulic head in the vicinity of the pit is estimated to be 1410 mamsl. Thus, the pit lake elevation is expected to remain well below the pre-mining head elevation and the pit will act as a groundwater sink post-closure.

k) The pit perimeter elevation is approximately 1415 mamsl and consequently, the depth to the pit lake, 200 years post closure, is approximately 81 m below the surface.

l) As the rate of rise slows and the role of evaporation increases, TDS concentrations within the pit lake are expected to rise.

4. RECOMMENDATIONS

- A Geotechnical study must be conducted to determine the pit stability for all the scenarios outlined in the geochemical report.
- The applicant must outline the financial implications for each proposed scenario.
- The Department of Water and Sanitation is in support of the option to completely backfill the pit to reduce human interference and other wild animals from accessing the pit site.
- The option to completely close the pit is preferred to avoid ingress that might increase groundwater contaminating the surrounding aquafers.
- The applicant must continue complying with the conditions detailed in the existing water use license.
- Regular follow up must be done with the Department's Licensing section for the application submitted for rehabilitation.

- The closure activities at Voorspoed mine must proceed as per the approved EMPr issued in July 2010 by the DMRE. Alternatively, the above-mentioned recommendations must be addressed and evaluated by this Department for approval.

- Post closure monitoring for the rehabilitation scenario that will be approved upon submission of the requested information must be implemented and mitigation measures be implemented to prevent any detected environmental impacts

You are welcome to contact Ms B Melato at telephone: 051 405 9000 or on e-mail: melatob@dws.gov.za should you have any enquiries.

Yours sincerely,

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PROVINCIAL HEAD: FREE STATE

DATE: 19/6/2023